The Food and Feeding Habits of the Cuttlefish *Sepiella inermis* (Férussac & d'Orbigny)

BY

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INTRODUCTION

THE CEPHALOPODS have been known for their economic potential as food. They are also of immense biological interest, being highly evolved molluscs with a degree of learning ability comparable to that of some vertebrates. Most of the investigations made in this group were on the species *Sepia officinalis* (WELLS, 1962) and "only in less than half a dozen do we know anything about the general biology, physiology and reproduction" (ADAM & REES, 1966).

Practically no studies have been conducted on the cuttlefishes in waters around Singapore. The aim of the present investigation is to study the food and feeding habits of *Sepiella inermis* (Férussac & d'Orbigny), a species of cuttlefish found in local waters.

BIDDER (1966) stated that all known living cephalopods studied are active predators, swimming in pursuit of their prey. *Sepia officinalis* has been observed to feed on crabs, prawns, shrimps and fish by many workers (MESSENGER, 1968; WELLS, 1962, and WILSON, 1946). FÉRUSSAC & D'ORBIGNY (1848) also observed *Sepiola atlantica* feeding on small molluscs and fish, while *Idiosepius* sp. was seen feeding on gammarids (SASAKI, 1929). But no report has been made so far on *Sepiella inermis*.

MATERIALS AND METHODS

Sepiella inermis is identified by its ovate mantle with chromatophores concentrated in the mid-dorsal region; it can be distinguished from other cuttlefishes by the series of shiny white elliptical markings on the margin of the mantle at the base of the fins. These ellipses numbered from 7 to 9 pairs. Just anterior to the junctions where the fins meet posteriorly is a round brown spot marking the position of a gland which opens on to the ventral side via the glandular pore. The cuttlebone of this species lacks the rostrum which is present in other *Sepia* species (ADAM & REES, 1966).

Specimens were collected from a kelong, a fixed palisade trap, using light as a lure to attract fish, in the Straits of Johore, situated to the north of Singapore Island. *Sepiella inermis* were caught individually with a scoop net. Special care was taken not to injure the specimens which were required live for laboratory studies. Slight injury of the thin epithelium often resulted in a high mortality in the laboratory in less than 3 days. The animals were transported to the laboratory in polyethylene bags containing a few centimeters of seawater and an atmosphere of oxygen.

In the laboratory live animals were carefully kept in clean plastic tanks (35 cm × 18.3 cm × 21.5 cm) with a layer of about 4 cm of coral sand and 3 l of seawater. Rubber gloves were used when handling or transferring the animals. Temperature was kept at about 25 to 27° C. Continuous aeration of the water was essential because the oxygen consumption of the animals is high and the cephalopod respiratory mechanism is not adapted to cope with any downward fluctuation of oxygen, even of the most temporary nature (WELLS, 1962). Care was taken not to excite the animals whose sudden movements normally resulted in injury due to collision with the tank walls. Sudden flashes of light from lamps and movements of objects or people were kept at a minimum. To minimise the effects of these factors, the aquarium tanks were kept behind curtains and covers.

Animals for the study of stomach contents were preserved in 5 to 10% formalin immediately after capture.

Temporal variations in diet and feeding habits of adult and juvenile *Sepiella inermis* were evaluated by the monthly percentage occurrence of the types of food consumed as well as the monthly feeding intensities by examining the stomach contents of the specimens caught in the field. At the same time, experiments in the laboratory were designed to test the food selectivity of *S. inermis* with different types and sizes of prey and the results were compared with the field data.

Stomach Contents

For the study of stomach contents, specimens were caught at fortnightly intervals at the collection site. The mantle length, the distance between the tip of the mantle and the junction of the fins at the posterior end, and the mantle width at the broadest region of each specimen were measured. Each individual was considered as immature or juvenile when no sexual organs were detected. Mature specimens were identified from the sexual organs, such as testes and genital duct in the males and ovaries and nidamental bodies in the females.

A total of 71 stomachs were examined and the percentage number feeding was calculated for each month as a measure of monthly feeding intensity of the population from the formula

$$\frac{\text{number of stomachs with food}}{\text{total number of stomachs examined}} \times 100$$

The specimens examined were divided into 3 categories: juveniles, adult males, and adult females.

The degree of feeding for each individual was also noted and classified in the following manner:

- E – 'empty' – when the stomach was empty
- S – 'slight' – when the stomach was not distended and there was little food
- M – 'medium' – when the stomach was slightly distended with food
- H – 'heavy' – when the stomach was fully distended with food and usually occupied $\frac{1}{3}$ of the mantle cavity

and the proportions of stomachs for each degree of feeding were also calculated for each month.

The percentage monthly occurrence of each food type consumed by the animal was calculated by

$$\frac{\text{number of stomachs with food type}}{\text{total number of stomachs examined}} \times 100$$

The percentage monthly occurrence of the food item was determined for 2 size categories of *Sepiella inermis*: those smaller than 25 mm (immature) and those larger than 25 mm (mature) in mantle length. The 25 mm length coincided with the length of the smallest mature specimen examined.

Laboratory Experiments

In the laboratory 2 experiments were carried out: one to determine the selectivity of *Sepiella inermis* towards prey types and the other to determine the selectivity towards the prey size.

Animals used were acclimated for a period of at least 3 days. They were then starved before the start of each experiment. This was to minimize the differences in the degree of hunger. Each experimental animal was kept in a separate tank so that no complications, such as interference from or social facilitation between predators was present (Holling, 1966).

To determine food preference, prey types offered to the predator were fish (*Poecilia reticulata*), prawns (*Acetes* sp.) and crabs (*Dotilla* sp.). These prey animals corresponded quite closely to the type and size of prey consumed by *Sepiella inermis* in the natural environment. At the start of the experiment, 10 of each prey type were offered simultaneously to the predator. After half an hour, the remainder of each type of prey left uneaten was noted. Two sizes of cuttlefish and 2 individuals of each size class were studied. The sizes within each prey type offered were kept as constant as possible:

Poecilia reticulata – 20 mm standard length
Acetes sp. – 3 to 5 mm carapace length
Dotilla sp. – 20 mm carapace width

In the experiment designed to study the effect of prey size on food preference, only *Poecilia reticulata* were offered because it was the only prey type that was readily eaten by all sizes of cuttlefish. The 2 sizes of *Poecilia reticulata* offered were 10 mm and 30 mm standard length. Two sizes of predators, 20 mm and 40 mm mantle length, were studied. On the first day of the experiment, a mixed offer consisting of 5 10 mm and 5 30 mm *P. reticulata* was presented. Two days later, a pure offer consisting of 10 10 mm fish was made and subsequently, after another 2 days a pure offer of 10 30 mm prey animals was made. At the end of half an hour after each offering, the remaining number of prey animals of each size group was noted. The intervals of 2 days between each 2 feedings were made to insure that all the predators were properly starved. Three replicates were conducted for each size group of predators.

RESULTS

Predatory Behaviour

The capture of fish by *Sepiella inermis* is similar to that described for the capture of prawns by *Sepia officinalis* (Messenger, 1968). The whole predatory behaviour is composed of 3 main phases: attention, positioning, and seizure.

When the prey (*Poecilia reticulata*) was offered, the eyes of *Sepiella inermis,* which normally rested half-buried in the sandbed, were seen to focus on the prey and follow its movements for a few seconds. Then the cuttlefish elevated itself slowly out of the sandbed and swam towards the prey. At the same time, during this "attention" phase, a general darkening of the body was observed.

The cuttlefish approached the prey slowly and positioned itself at a distance about its own body length away from the prey. In a few individuals this positioning was followed by the raising of its first and second pair of arms. It is suggested that this behaviour, which was also observed by MESSENGER (1968) in other species, probably serves to distract the prey. However, in the majority of *Sepiella inermis*, this raising of arms was not observed. Whenever the prey moved, the cuttlefish followed, thus always positioning itself in line with the prey.

In some individuals the prey was seized soon after positioning while in others the predator remained stationary in midwater for some time before attacking. In healthy cuttlefish during the seizure phase the tentacles were projected at the prey with great precision. However, the tentacles were not so effectively employed to capture the prey by cuttlefish which had been kept in aquaria for more than 4 weeks. These cuttlefishes appeared to have lost their ability to project their tentacles with accuracy. The projected tentacles did not seem to extend to their fullest and often fell short of the prey. These cuttlefishes often capture their prey with their arms instead. This change in behaviour was often observed in cuttlefish a few days prior to their death. This symptom may be indicative of an unhealthy cuttlefish.

When crabs (*Dotilla* sp.) were offered, the attention and the positioning phases were similar to those described for the capture of fish, except that a longer time was spent hovering above the crab. The crab was seized either with the tentacles or with the arms. BOYCOTT (1958) and WILSON (1946) reported that attacks on crabs were made from the posterior end of the crab, probably to avoid the pincers. However, observations of *Sepiella inermis* confirmed MESSENGER's (1968) report that head-on attacks were also made. The direction of attack was probably determined by the size of the prey's pincers and the state of hunger of the predator.

MESSENGER (1968) noted that *Sepia* discards the antennae and rostrum of prawns and the carapace, chelae, and walking legs of crabs. However, in starved *Sepiella inermis* all parts of the crab and fish were consumed, while individuals which had already consumed a few prey specimens often discarded fish heads.

MESSENGER (1968) suggested that prey animals were probably killed by cephalotoxins injected into them by the predator. However, *Poecilia reticulata* removed from *Sepiella inermis* after the first bite were found to survive up to 15 minutes, which is longer than that recorded for prawns seized by *Sepia* sp. (MESSENGER, *op. cit.*). It would appear that the cephalotoxin of *Sepiella inermis* was either absent or not as potent as that found in other species of cuttlefish.

Food Preference and Feeding Intensity

Generally the monthly percentage number feeding in the juvenile, adult male and adult female *Sepiella inermis* was high throughout the period of this study (Table 1) indicating that feeding was continuous and probably non-seasonal. The females showed the highest percentage number feeding, with the lowest percentage number shown by the juveniles. This low percentage feeding index of the juvenile could probably be due to the inavailability of suitable prey animals of the right size.

The juveniles fed moderately in the months of April and July, and heavily in May and June as shown by the monthly feeding intensity (Table 2). About 50% of the mature males generally showed heavy feeding in all the months except in April. The mature females generally

Table 1

Percentage Feeding in Juvenile, Adult Male and Adult Female *Sepiella inermis*

Month	Juveniles		Adult Males		Adult Females	
	% feeding	No. exam.	% feeding	No. exam.	% feeding	No. exam.
April	100	2	100	4	100	2
May	50	2	100	17	78.5	8
June	50	4	50	2	100	2
July	100	2	89	9	100	2
August	–	–	75	8	100	4

showed moderate feeding, with some feeding heavily in August. Apparently, the males are much more voracious feeders than the females and the juveniles.

The monthly percentage occurrence of food items in the stomachs examined (Table 3) clearly indicates a preference for prawns (*Acetes* sp.) by the smaller *Sepiella inermis* throughout the months of this study. Both fish (mainly *Stolephorus* sp.) and prawns (mainly *Acetes* sp.) were consumed by the larger cuttlefish. Both food items fluctuated slightly in their monthly occurrence in the diet of the predator. Crabs were found in the stomachs only in May. The crabs eaten were mainly xanthid crabs, *Sphaerocius* sp. and *Porcellana* sp.

Laboratory experiments on food preference showed that the smaller-sized *Sepiella inermis* fed chiefly on *Poecilia reticulata,* with one *Acetes* sp. eaten by one of the 2 cuttlefish (Table 4). The larger cuttlefish showed a preference for *P. reticulata,* but they also fed on *Acetes* sp. and *Dotilla* sp., which were eaten in almost equal numbers.

In the experiment on size selectivity, *Sepiella inermis* of the 15 to 20 mm size class chose only the smaller prey (Table 5). Each of the 3 cuttlefish took only 3 fish which is probably their feeding capacity for prey about 10 mm in length. When a pure offer of 30 mm prey was presented only one fish was taken per meal. It would appear, therefore, that when choice is available, as in the mixed offer, the smaller *S. inermis* exhibited a definite preference for smaller prey.

The larger *Sepiella inermis* do not show a distinct preference for any particular size of prey. In the mixed offer, both sizes of prey were eaten in almost equal numbers (Table 5).

Table 2

Monthly Feeding Intensity in Relation to Sex and Maturity

Types	Juveniles Feeding Intensity					Adult Males Feeding Intensity					Adult Females Feeding Intensity				
Month	H	F	S	E	No. exam.	H	F	S	E	No. exam.	H	F	S	E	No. exam.
April	0	0	2	0	2	0	1	2	0	3	0	2	0	0	2
May	1	0	0	1	2	4	6	5	0	15	0	2	8	2	12
June	1	1	0	2	4	1	0	0	1	2	0	0	2	0	2
July	0	1	1	0	2	4	2	2	1	9	0	2	0	0	2
Aug.	–	–	–	–	–	4	1	3	0	8	1	2	1	0	4

H: Heavy feeding
F : Full stomach
S : Slight feeding
E : Empty stomach

Table 3

Percentage occurrence of Food Items in the Stomach of the Two Size Groups of *Sepiella inermis*

Size of cuttlefish	< 25 cm Mantle Length: Number with different food type				> 25 cm Mantle Length: Number with different food type			
Month	Prawn	Fish	Crab	No. exam.	Prawn	Fish	Crab	No. exam.
April	2	0	0	2	4	10	0	14
May	2	0	0	2	9	18	5	26
June	2	0	0	2	9	4	0	9
July	3	0	0	3	9	4	0	11
August	–	–	–	–	5	5	0	9

Table 4

Number and Types of Prey Consumed in Half an Hour by the Two Size Groups of *Sepiella inermis* given a Mixed Offer of Ten Individuals of each Prey Type

Size of *Sepiella inermis*	Replicate Number	Prey Type *Poecilia reticulata*	*Acetes* sp.	*Dotilla* sp.
15 - 20 mm	1	2	1	0
	2	3	0	0
40 - 45 mm	1	6	2	1
	2	4	2	2

Acetes sp., are more easily captured than *Stolephorus*.

However, in the laboratory more fish than prawns were consumed by the juvenile predator, although both prey species appeared to be equally slow swimmers. This preference is probably due to the visual difference between the 2 types of prey. *Poecilia reticulata* are usually coloured and more opaque than the *Acetes,* which are more transparent. The former species is therefore probably more easily detected by *Sepiella inermis.* Illumination intensity in the laboratory may be higher than that in the sea and the transparent-looking *Acetes* under such conditions would probably be difficult to detect.

Table 5

Prey Size Preference by Two Size Groups of *Sepiella inermis* (ten prey individuals per size group were offered at any one time)

Size of *Sepiella inermis*	Replicate Number	No. of *Poecilia reticulata* consumed in ½ hour: Mixed Offer 10 cm	Mixed Offer 30 cm	Pure Offer 10 cm	Pure Offer 30 cm
15 - 20 mm	1	4	0	2	1
	2	3	0	3	0
	3	3	0	3	1
40 - 45 mm	1	4	3	5	3
	2	3	3	5	5
	3	3	2	5	4

DISCUSSION

Boycott (1958) and Wells (1962) have suggested that young *Sepia officinalis* feed instinctively on mysids; then they learn to feed on other prey as they grow older. This is probably not the reason why only *Acetes* sp. were found in the stomachs of juvenile *Sepiella inermis.* Since laboratory experiments showed that juvenile *S. inermis* can feed on prey other than prawns, it indicates that *Acetes* consumption in the natural environment is not governed by instinct alone, but rather by the ease of capture of the prey. In the natural environment juvenile cuttlefish were probably unable to capture the larger and faster swimming prey, such as *Stolephorus* sp. The preference for smaller *Poecilia reticulata* in the laboratory experiment also indicates the relative inability of smaller *S. inermis* to capture larger and faster swimming prey. Thus, in the natural environment smaller and slower swimming prey, such as

Adult *Sepiella inermis,* on the other hand, feed on both *Stolephorus* and *Acetes* in the natural environment. They are faster swimming and therefore able to capture the faster swimming prey, such as the *Stolephorus* sp.

Both *Stolephorus* and *Acetes* are available in the seas around Singapore throughout the year, but their availability is generally low in May (Khoo, 1966). It is interesting to note that during this month crabs are also found in the diet of adult *Sepiella inermis.* These crabs are normally found on the "kelong" poles and are readily available. It would appear, therefore, that crabs are not eaten when the other food items, such as *Acetes* and *Stolephorus*, are abundant, but are only consumed when the latter food items are low in availability.

Laboratory observations also showed a selectivity against crabs. The crabs, using their pincers, threaten and discourage all but the biggest and most hungry cuttlefish.

The burrowing habits of the crabs may also make detection and capture difficult.

In conclusion, it appears that *Sepiella inermis* generally feeds on *Stolephorus* sp. and *Acetes* sp., with its feeding intensity and selectivity determined by the availability, the size, and the escape capability of the prey as well as the size and predatory response of the cuttlefish.

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